THE MARS CLIMATE DATABASE, CURRENT STATUS AND FUTURE IMPROVEMENTS

E. Millour[(1)], F. Forget[(1)], A. Spiga[(1)], S. Lebonnois[(1)], S.R. Lewis[(2)], L. Montabone[(3)], P.L. Read[(3)],M.A. López-Valverde[(4)], F. González-Galindo[(4)], F. Lefèvre[(5)], F. Montmessin[(5)], M.-C. Desjean[(6)], J.-P. Huot[(7)]
and the MCD/GCM development team

[(1)]Laboratoire de Météorologie Dynamique, IPSL, Université Pierre et Marie Curie, BP99, 4 Place Jussieu, 75005, Paris, France, Email: ehouarn.millour@lmd.jussieu.fr
[(2)]Department of Physics and Astronomy, The Open University, Milton Keynes, UK
[(3)]Atmospheric, Oceanic & Planetary Physics, University of Oxford, UK
[(4)]Instituto de Astrofísica de Andalucía, Granada, Spain
[(5)]Laboratoire Atmosphères, Milieux, Observations Spatiales, IPSL, Paris, France
[(6)]Centre National d'Etudes Spatiales, Toulouse, France
[(7)]European Space Research and Technology Centre, European Space Agency, Noordwijk, Netherlands

What is the Mars Climate Database?

The Mars Climate Database (MCD) is a database of meteorological fields derived from General Circulation Model (GCM) numerical simulations of the Martian atmosphere and validated using available observational data. The MCD includes complementary post-processing schemes such as high spatial resolution interpolation of environmental data and means of reconstructing the variability thereof.

The GCM is developed at Laboratoire de Météorologie Dynamique du CNRS (Paris, France) [1,2] in collaboration with the Open University (UK), the Oxford University (UK) and the Instituto de Astrofisica de Andalucia (Spain) with support from the European Space Agency (ESA) and the Centre National d'Etudes Spatiales (CNES).

The MCD is freely distributed and intended to be useful and used in the framework of engineering applications as well as in the context of scientific studies which require accurate knowledge of the state of the Martian atmosphere. Since its release in May 2008, Mars Climate Database v4.3 has been distributed to over 130 teams around the world. Current applications include entry descent and landing (EDL) studies for future missions (ExoMars, MSL), investigations of some specific Martian issues (via coupling of the MCD with homemade codes), analysis of observations (Earth-based as well as with various instruments onboard Mars Express and Mars Reconnaissance Orbiter),...

The MCD may be accessed either online (in a somewhat simplified form) via an interactive server available at http://www-mars.lmd.jussieu.fr (useful for moderate needs), or from the full DVD-ROM version which includes advanced access and post-processing software (contact millour@lmd.jussieu.fr and/or forget@lmd.jussieu.fr to obtain a free copy).

Overview of MCD contents

The MCD provides mean values and statistics of the main meteorological variables (atmospheric temperature, density, pressure and winds) as well as atmospheric composition (including dust and water vapor and ice content), as the GCM from which the datasets are obtained includes both chemistry [3] and full water cycle [4] models.

The database extends up to ~350km, i.e. up to and including the thermosphere[5,6]. Since the influence of Extreme Ultra Violet (EUV) input from the sun is significant in the latter, 3 EUV scenarios (solar minimum, average and maximum inputs) account for the impact of the various states of the solar cycle.

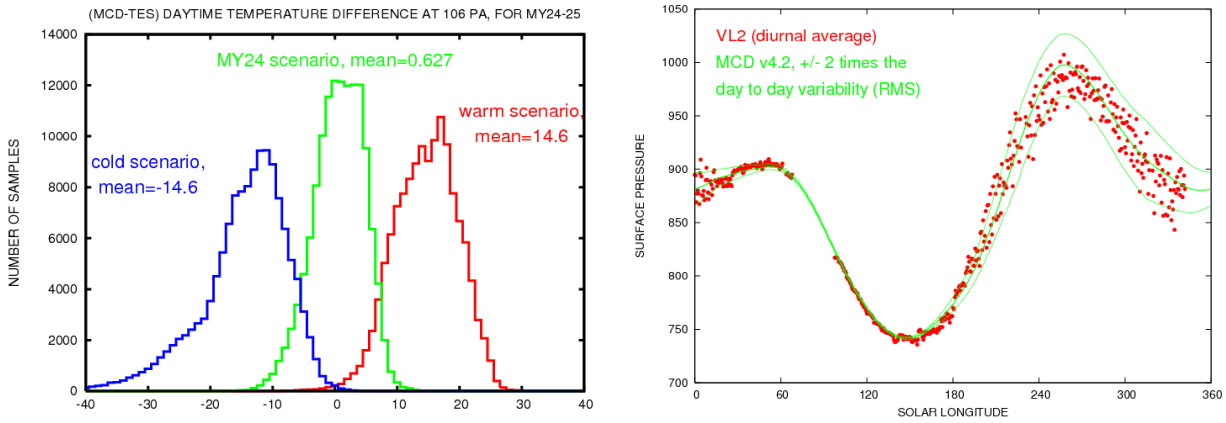
In order to account for and adequately represent the variability of the Martian atmosphere due to atmospheric dust distribution, the MCD includes 4 different dust scenarios which describe extreme cases (from very clear skies to global planet-wide dust storms) and a baseline scenario “MY24” for which the dust loading of the atmosphere is that obtained from assimilation of TES observations [7] in 1999-2001 (i.e. during Mars Year 24, following the calendar proposed by R.T. Clancy [8], which starts on April 11, 1955, at Martian solar longitude Ls=0°).

The following values are provided in the MCD:

- Atmospheric density, pressure, temperature and winds (horizontal and vertical),
- Surface pressure and temperature,
- CO_2 ice cover,
- Atmospheric turbulent kinetic energy,
- Thermal and solar radiative fluxes,
- Dust column opacity and mass mixing ratio,
- [H_2O] vapor and [H_2O] ice columns and mixing ratios
- [CO], [O], [O_2], [N_2], [CO_2], [H_2] and [O_3] volume mixing ratios,
- Air specific heat capacity, viscosity and molecular gas constant R.

Validation of the MCD Climatology

The MCD has been validated using available data, from TES, onboard MGS, for surface and atmospheric temperature, but also from atmospheric temperature retrieved from radio occultation using the ultra-stable oscillator onboard MGS. The assessment of the correctness of the surface pressure predictions was obtained using Viking Lander 2 measurements. The MCD includes a **validation document** which reports all the comparisons between MCD outputs and available datasets of measurements.



Left: Distributions of binned temperature differences (using bins of 1K) between MCD predictions (using different dust scenarios) and TES measurements for latitudes ranging from 50°S to 50°N. Displayed MEAN and RMS values are computed from the obtained histograms and the curves correspond to normal distributions of same MEAN and RMS.
Right: Surface pressure cycle over a Martian year, as predicted by the baseline **MY24** scenario at Viking Lander 2 site, with an envelope of twice its standard deviation, compared to recorded values.

Towards the next version of the MCD

We are currently working on a building a new and improved Mars Climate Database (version 5). One essential step towards this achievement is running an improved version of the GCM which will include all recent improvements and developments [9]:

- An improved CO_2 cycle resulting from the inclusion of realistic subsurface water ice tables in the Polar Regions [10].
- Improved radiative transfer with updated radiative properties of dust, along with the implementation of the radiative effect of water ice clouds [11].
- An improved water cycle [9,11].
- An updated chemistry package [12].
- An improved representation of the non LTE (Local Thermodynamical Equilibrium) phenomena in the thermosphere [13].
- We plan to update the thermal inertia and albedo maps used by the GCM.

- We will take into account the recently derived map of surface roughness values [14] (instead of using a fixed value of 1cm everywhere, as we have so far).
- We are also currently working on implementing the “thermal plume model” [15], a significant improvement to the current convective adjustment scheme in the GCM.

In addition to these technical improvements of the LMD GCM itself, we will include in Mars Climate Database version 5 more dust scenarios, which will include all Mars Years from MY24 to MY29 (as derived by [16]). Again some “extreme” (cold, warm, global dust storm) scenarios will also be provided to bracket reality as best as possible.

We also plan to improve the MCD software with the addition of a subgridscale variability near the surface, where the nature and amplitude of this added variability would be derived from simulations using the LMD Mars Mesoscale Model [17].

References

[1] Forget F. et al. (1999) *JGR*, 104, E10.
[2] Lewis S. R. et al. (1999) *JGR*, 104, E10.
[3] Lefèvre F. et al. (2004) *JGR*, 109, CiteID E07004.
[4] Montmessin F. et al. (2004) *JGR*, 109, E10, CiteID E10004.
[5] Angelats I Coll et al. (2005) *Geophys. Res. Lett.*, 32, 4, CiteID L04201.
[6] Gonzalez-Galindo F. et al. (2005) *JGR.*, 110, E9, CiteID E09008.
[7] Montabone L. et al. (2006) *2nd Int. Workshop on Mars Atmosphere Modeling and Observations*.
[8] Clancy R.T. et al. (2000) *JGR*, 105, E4.
[9] Forget et al (2011*) 4th Int. Workshop on Mars Atmosphere Modeling and Observations*.
[10] Millour E. et al. (2009) *3rd Int. Workshop on Mars Polar Energy Balance*.
[11] Madeleine J.-B. et al. (2011) *4th Int. Workshop on Mars Atmosphere Modeling and Observations*.
[12] Lefèvre F. et al. (2011) *4th Int. Workshop on Mars Atmosphere Modeling and Observations*.
[13] Lopez-Valverde M. A. et al. (2011) *4th Int. Workshop on Mars Atmosphere Modeling and Observations*.
[14] Vistowski C. et al (2011) *4th Int. Workshop on Mars Atmosphere Modeling and Observations*.
[15] Rio C. and Hourdin F. (2008) *J. Atmos. Sci., 65, 407-425*.
[16] Montabone et al. (2011) *4th Int. Workshop on Mars Atmosphere Modeling and Observations*.
[17] Spiga A. and Forget F. (2009) *JGR*, 114, CiteID E02009